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A study of the Oystercatcher *(Haematopus ostralegus* L.*)* in relation to the fishery for cockles *(Cardium edule* L.*)* in the Burry Inlet, South Wales

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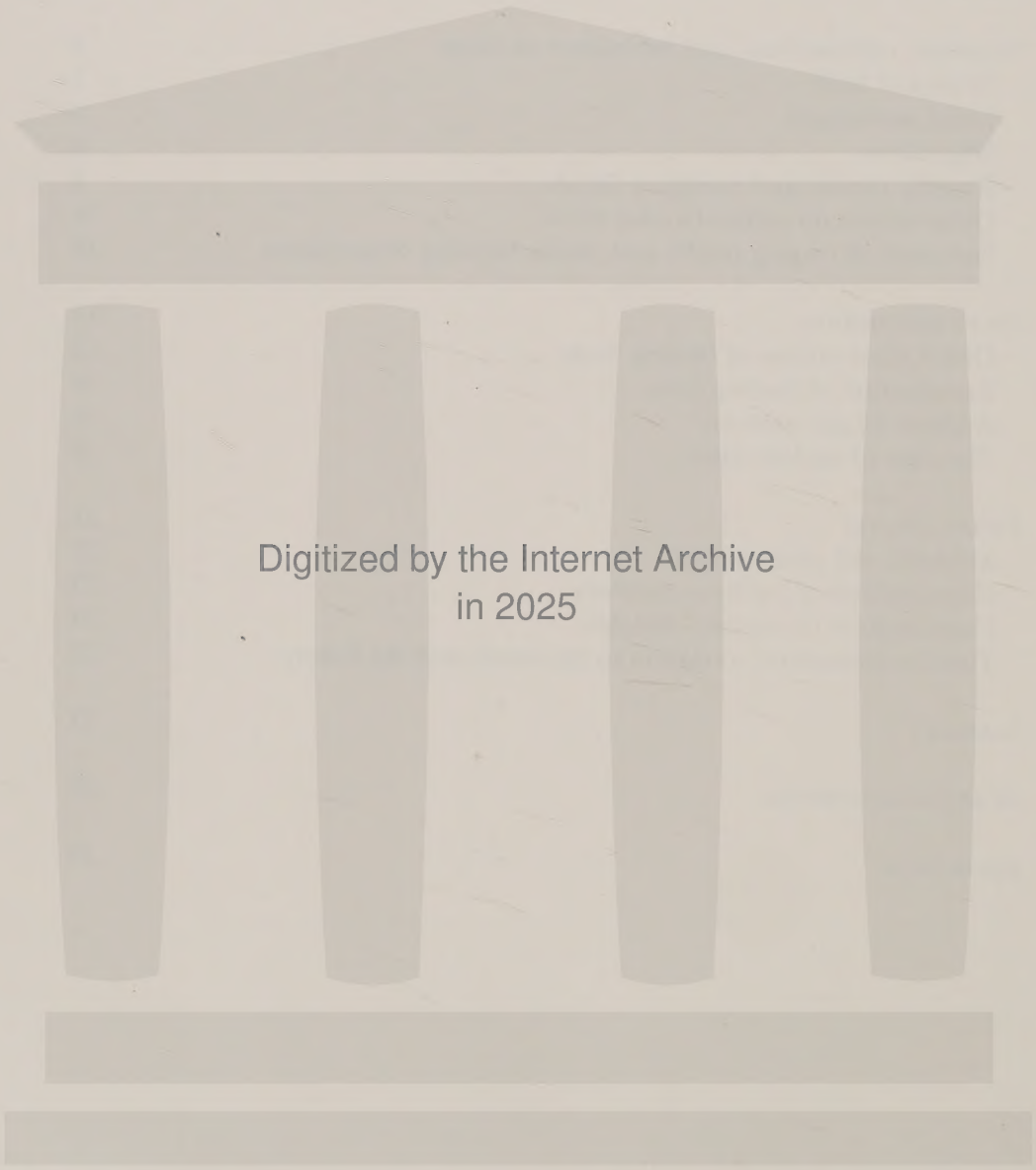
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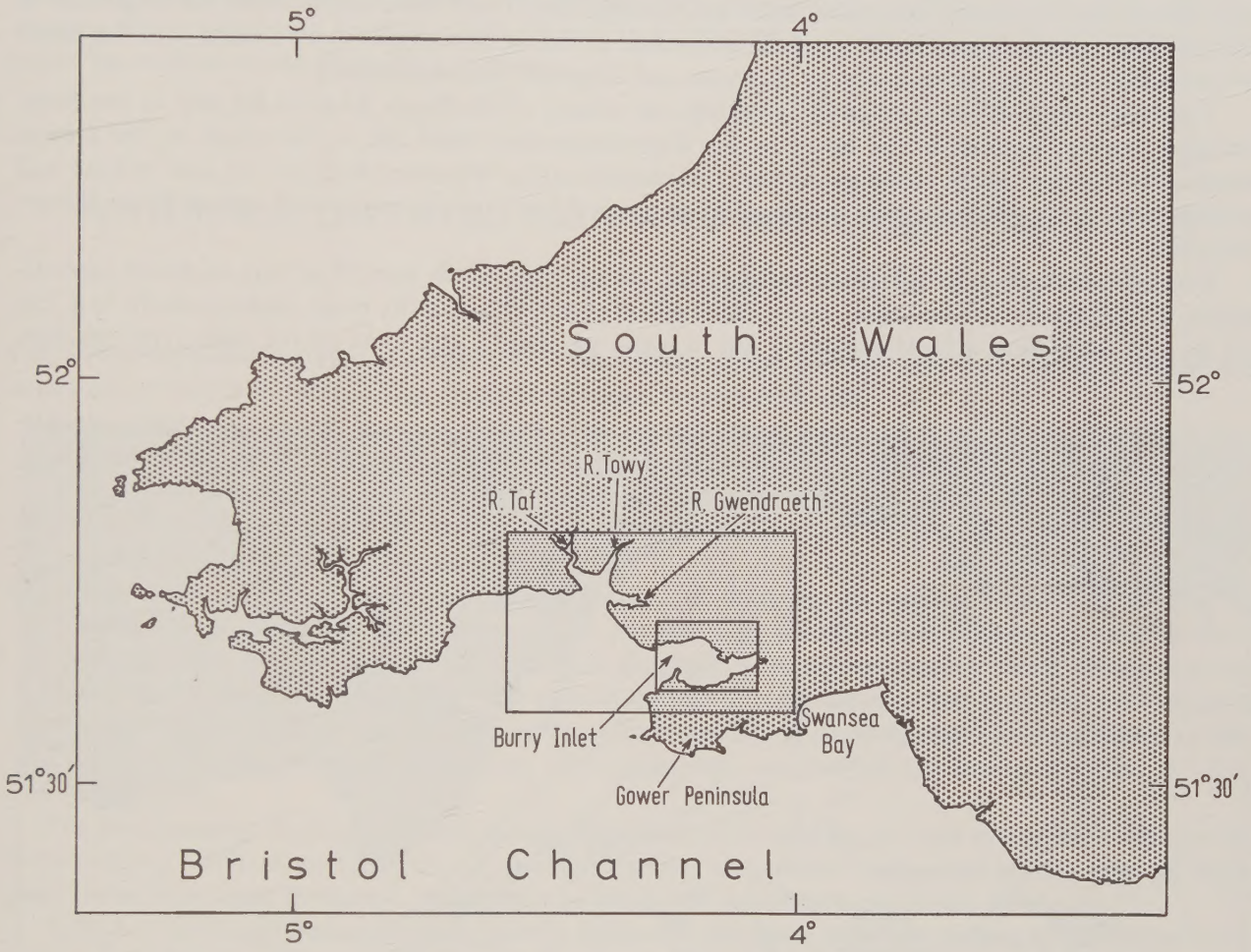

Fig. 1. *Map of South Wales, showing the main wintering grounds of Oystercatchers in the area (larger rectangle) and the Burry Inlet (smaller rectangle)*

INTRODUCTION

THE Burry Inlet, in South Wales, is the centre of a substantial fishery for cockles (*Cardium edule* L.) which employs nearly a hundred licensed fishermen, and others operating processing plant. Recorded landings over the years 1958-64 have ranged between 11 000 and 35 000 cwt though actual yields are known to have been greater in earlier years (Hancock and Urquhart 1966). The South Wales Sea Fisheries Committee had for many years contended that the Oystercatcher (*Haematopus ostralegus* L.) was a serious pest of the fishery, but a brief investigation carried out during the autumn of 1956 led to the conclusion that at that time it was not a serious threat to the industry (Drinnan and Cole 1957). However, complaints continued.

A separate investigation into the cockle fishery and the means of obtaining the maximum yield by management was started in 1958 by Hancock, and this has provided a great deal of detailed information on the cockle stocks, their exploitation and natural enemies. During this work the importance of the Oystercatcher as a predator became apparent (Hancock and Urquhart 1965) and in 1960 a new programme of work on the role of the Oystercatcher in the Burry Inlet was started by the author.

The present report describes the results of this work and is mainly concerned with observations of numbers of Oystercatchers, their movements and feeding rates. From these observations the magnitude of the predation on the cockle stock has been estimated, so that a comparison can be made with the losses of cockles from all causes recorded by Hancock and Urquhart (in preparation).

The Burry Inlet (Figures 1 and 2) comprises the estuary of the Burry River as far east as the River Loughor and is bounded to the north by the Carmarthenshire coast and to the south by the Gower Peninsula. The Inlet opens to the west where it is constricted by Whiteford Burrows, an area of fixed and mobile sand dunes which projects northwards for about 2 km from the north-west corner of the Gower Peninsula.

The Inlet, excluding the peripheral saltmarshes, covers some 50 sq. km (20 sq. mi), of which approximately 80% dries out at low water. The cockle beds of commercial density cover approximately 3 sq. km ($1\frac{1}{4}$ sq. mi) running as a band roughly $\frac{1}{2}$ km in width parallel to and south of the main river channel.

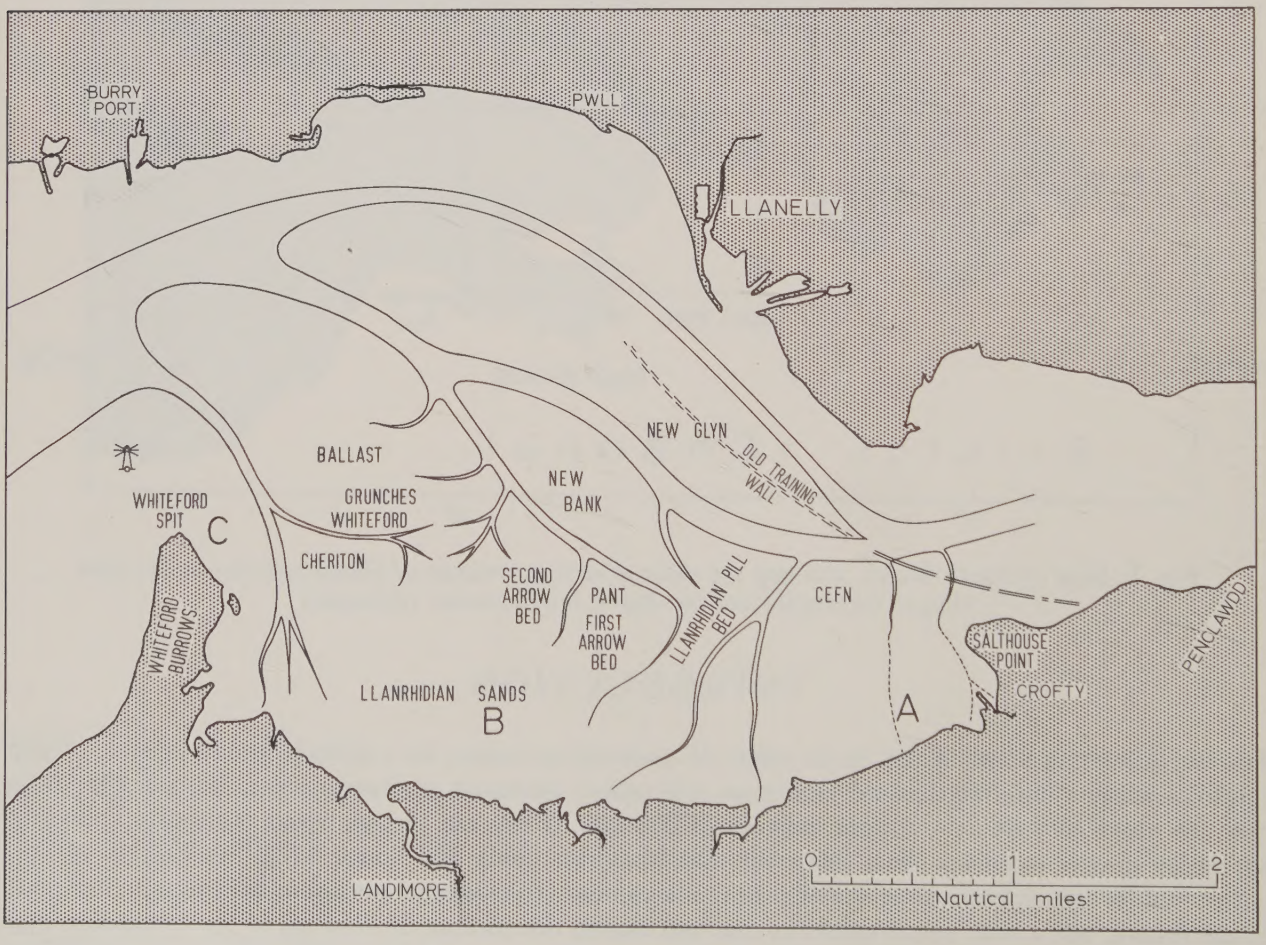

Fig. 2. *The Burry Inlet, showing the main cockle beds*

There is also a smaller productive area towards the northern bank of the estuary, near Pwll and Llanelly. These cockle beds are named in Figure 2.

It is in the former area, known as the Llanrhidian Sands, that the main flocks of birds are to be found and that the major part of the work to be described has been done. The counts of Oystercatchers have however covered the whole area within the Burry Inlet which is exposed at low water, since the feeding areas vary with weather conditions and with changes in the density of the cockles. Additional counts were made in the neighbouring Taf-Towy Inlet (Figure 1) at times when it appeared that Oystercatchers there might be involved in the Burry Inlet problem.

NUMBERS, DISTRIBUTION AND MOVEMENT OF BIRDS

COUNTS OF BIRDS

COUNTS of the birds feeding on the sands have been made almost every month since August 1961 and the totals are set out in Table 1. Three methods of counting were available:

(i) An observer on the beach could make a direct count of the birds roosting in each flock at high water. This method proved impracticable when the main winter flocks were present, due to the close packing of the birds and the high numbers involved.

(ii) Aerial photographic counts of birds on high-water roosts have been used to cross-check direct counts on the grounds.

(iii) The usual method adopted was the direct count of birds on the feeding grounds. The observer walked or drove along the beach as soon as possible after the tide had receded and while the birds were spread out and feeding. The sands are traversed by numerous gutters which divide them up into banks and flats, and using $\times 10$ binoculars and a $\times 60$ telescope the birds on each of these areas could be easily counted. Trials by two observers making simultaneous but independent counts gave, on the two occasions when they were attempted, totals agreeing within $\pm 3\%$ and $\pm 1 \cdot 5\%$ respectively.

The photographic methods of Drinnan and Ridpath (1957) could not be used in the Inlet, because the birds were very difficult to approach on the marsh roosts and tended to rise and scatter from all three major roost sites when disturbed, rather than to stream off in any one particular direction.

A flock of birds numbering between 500 and 1 500 was usually to be found feeding on the mussel beds surrounding Whiteford Lighthouse. This flock normally roosted on the western shore of the Burrows but on spring tides was liable to be driven round the point to roost with the cockle-eating birds from the Inlet. Colour-banding observations in Morecambe Bay and North Wales by Dare (in preparation) have indicated that where cockle- and mussel-eating birds are to be found in close proximity there is very little interchange between the feeding grounds. On account of this evidence and the day-to-day similarity of numbers of birds feeding on the Whiteford mussel scar, we have omitted these from our totals and from calculations relevant to the cockle fishery.

Although care was taken to cover all likely feeding areas during the counts the totals often appeared low during periods of very rough weather. This may have been due to flocks taking shelter in the lee of high banks and being overlooked. Since autumn 1963 a vehicle has been used while making counts and this has made possible a more complete coverage in the time available, resulting in more accurate counts in bad weather.

Moving from east to west the normal distribution of flocks on the sands showed small scattered parties of birds below Penclawdd, with the first major concentration on the Cefn (see Figure 2). The highest

Table 1. *Counts of Oystercatchers in the Burry Inlet*

	1960–61	1961–62	1962–63	1963–64	1964–65	1965–66
June	x	x	70	x	2 300	1 200
July	x	x	630	1 240	4 060	x
August	x	3 000	4 370	3 640	7 800	2 200
September	x	x	9 520	x	9 530 (3 000)	9 650
October	x	10 170	6 200	x	7 800	9 000
November	x	11 470	8 800	5 520	6 750	15 800
December	8 830	11 970	14 100 (2 000)	3 740 (5 000)	10 500 (5 000)	11 500 (2 500)
January	x	10 660	8 500	3 000 (6 000)	10 500 (3 200)	11 500
February	x	6 000	6 600	1 690	8 600 (1 100)	7 200 (4 500)
March	3 350	2 290	5 160	1 700	4 560	1 300
April	x	10	2 700	2 500	2 200	2 150
May	x	nil	2 690	1 400	200	800 (1 400)
Average October-March		8 760	8 230	3 130	7 870	9 380

x—denotes no count made
Figures in parentheses are the simultaneous estimates for Oystercatcher flocks in the Taf-Towy estuaries

counts were, however, usually made on the Ballast and Grunches areas. This is a vast flat expanse of sand, and high counts were due to the extent of the area rather than to a high density of feeding birds. The highest *densities* of birds were usually found feeding around the areas known as First Arrow and Second Arrow beds, and it was here that observations on feeding birds were most frequently made.

LOCAL MOVEMENTS

Local movements are here taken to include irregular movements between the estuary and adjacent bays as well as daily movements from the feeding grounds and back, but do not include movements into or out of the South Wales area generally, which are considered as migratory movements.

Usually the birds began to move from the roosts at about two hours' ebb, and flew direct to the tops of the higher banks which were by this time exposed. As the tide fell the birds moved along the beach and spread out to feed on any part of the commercial cockle grounds. At about the time of low water the birds often concentrated into quite dense roosting flocks along the edges of the gutters, particularly if there was a strong wind blowing, suggesting that they may have been using the protection afforded by the banks of the gutters. From these low-water roosts, the birds again spread out to feed as the tide flooded. When driven from the feeding grounds by the rising tide, the birds formed into "intermediate sand" flocks similar to those described in Morecambe Bay by Drinnan (1957). From the sand flocks they would fly either directly to a roost, or along the beach to join other flocks before moving to the high-water roost. On the more steeply sloped beaches the birds would usually be driven directly up the beach ahead of the tide and on to a roost.

The particular roost, or part of a roost, chosen by the birds depended primarily upon the part of the bed on which they had been feeding, and also on the wind strength and direction. The choice of feeding ground appeared to be largely influenced by the prevailing weather (movement being considerably restricted in adverse conditions) and, to a lesser degree, by the density and size of the shellfish. There were three main roosting areas (see Figure 2). The first, roost 'A' ,was on the open marsh to the west of Crofty village, and was used by the birds when the cockles were dense in the upper reaches of the Inlet, as during the autumn of 1962. In later years, following an even set of cockles over practically the whole beds, this roost was little used. Roost 'B'—a complex of roosts along the edge of the saltings below Landimore village—was also an open marsh site, frequently used except on big spring tides when it flooded and the birds were driven off. Area 'C' also comprised a complex of roosts. It extended around the northern tip of the Whiteford Burrows and was divided into the open western shore, where the birds from the offshore mussel scars roosted, and the north-eastern spit, which was the main roost for all the birds in the Inlet on spring tides. This third roost complex was regularly occupied, although on neap tides only by birds from the mussel scars surrounding Whiteford Lighthouse.

Although, during the period covered by these observations, there were wide variations in the numbers of birds in the whole area, even between consecutive months (Table 1), indications were that the Burry Inlet birds formed a fairly discrete flock. The areas nearest to the Burry Inlet where Oystercatchers also occurred regularly were the Taf-Towy estuary, four miles to the north-west, and Swansea Bay to the south-east (Figure 1). The flocks in Swansea Bay usually totalled only a few hundred birds, and other bays in the Gower held only a scattered few.

In the course of observations of the build-up and break-up of the roosting flocks and their movements around the Inlet at low water, few instances of birds moving into or out of the area were noted. During observations on the formation of the Whiteford roost particular attention was paid to the possibility of interchange of birds between the Taf-Towy area and the Burry Inlet, but no such movement was seen even when the birds were scared off the high-water roost. When an exceptionally high tide covered their roosts they seemed to prefer to disperse into small groups, which spent the high-water period circling

round searching for alternative roosts or as small scattered flocks, sometimes in the fields round the Inlet, rather than in flighting across to the Taf-Towy area. Movement at night could not entirely be ruled out although, in view of the fact that the flighting patterns which were observed were the same during both night and day from the feeding grounds to the roost, any deviation would seem unlikely.

Although it appears that the Burry Inlet flocks are normally discrete from year to year (see also the section on Ringing Returns), there is evidence that under certain conditions there may be a change in the usual distribution of the population of birds within the South Wales area. For example, in the winter of 1963/64 the number of commercial-sized cockles was very low, having been catastrophically reduced during the previous severe winter (Hancock and Urquhart 1964). There had, however, been a very good settlement of young cockles throughout both the Burry Inlet and the Taf-Towy estuary during 1963. Although this was the heaviest spatfall for many years, settlement of the brood cockles in the Burry Inlet did not seem as extensive or as dense as that in the Taf-Towy estuary. No samples of cockles were analysed from the Taf-Towy estuary, but the young cockles seen there in February 1964 were of the order of 15-18 mm in length, while those in the Burry Inlet were about 10 mm*.

In the Burry Inlet in the winter of 1963/64 Oystercatchers were observed to be feeding on a mixed diet of both brood and older cockles but in the Taf-Towy estuary they concentrated on brood cockles. It is presumed that in the Burry Inlet the return from effort spent in trying to find large cockles was too low, as first-winter or brood cockles formed a much larger part of the birds' diet than normal. During that winter the flocks of Oystercatchers in the Taf-Towy area rose to 5 000-6 000, compared with our own observed totals of 2 000-3 000 in previous years which local observers agreed were normal, whilst the Burry Inlet flocks fell from their usual 8 000-10 000 average to around 3 000 (Table 1). The Taf-Towy cockle beds are normally much less important commercially than those of the Burry Inlet (Hancock and Urquhart 1966), and it must be presumed that, just as the Burry Inlet beds are favoured by the fishermen on account of their greater productivity, so the birds normally obtained a better reward for their effort when feeding in that estuary. The relative numbers of birds in the two areas in the winter of 1963/64 may therefore be regarded as abnormal, associated with the differences in stocks of cockles.

The figures for the Taf-Towy flocks are only estimates but the indication is that from year to year the two areas may be treated together as the wintering ground of one Oystercatcher population, with the Burry Inlet as the main centre in normal years.

All colour-banding has been done in the Burry Inlet and there is a greater sighting rate of these birds in that area. Unfortunately no birds were colour-banded prior to 1963, so no check could be made on this shift of population by observations of colour-band frequency among the Taf-Towy birds in 1963.

MIGRATIONS

The large-scale movements into and out of the Burry Inlet at the beginning and end of the winter are evident from the changes in the numbers of birds present each month (Figure 3) and from the changes in the relative proportions of juvenile and adult birds in these flocks (Table 2).

During observations of the composition of the flocks, Oystercatchers have been classified into three age-groups according to plumage differences recorded in Witherby *et al.* (1941):

(i) Birds of the year, i.e. first-winter birds. These can easily be distinguished until midwinter when they moult their first plumage.

(ii) Immature (second- and third-year) birds. Normally from January onwards the term immature will cover first-year birds as well. The Oystercatcher does not reach maturity until at least its third year (Dircksen 1932).

(iii) Adults.

* All cockle measurements used in this paper refer to length, i.e. anterior/posterior axis

Table 2. *Composition of catches of Oystercatchers showing percentages of different age groups*

Date	Number in total sample	Adults	Percentage of	
			2nd-and 3rd-year immatures	First-winter birds
25 August (1964)	53	69·8	22·6	7·6
5 September (1963)	554	70·0	26·5	4·4
8 September (1964)	176	84·5	13·8	2·3
11 November (1962)	385	57·9	38·5	3·6
20 November (1964)	306	79·7	17·0	3·3

Each year a noticeable change occurred in the birds' behaviour over the winter months. When the flocks first arrived they were quite approachable, but as the season progressed the birds became more and more wary until, at the end of the winter, the slightest sound or movement was enough to put the flocks into flight. This change may have been associated with the approach of the migration period, or alternatively may just have been a reaction to shooting by wildfowlers in the area during the winter months.

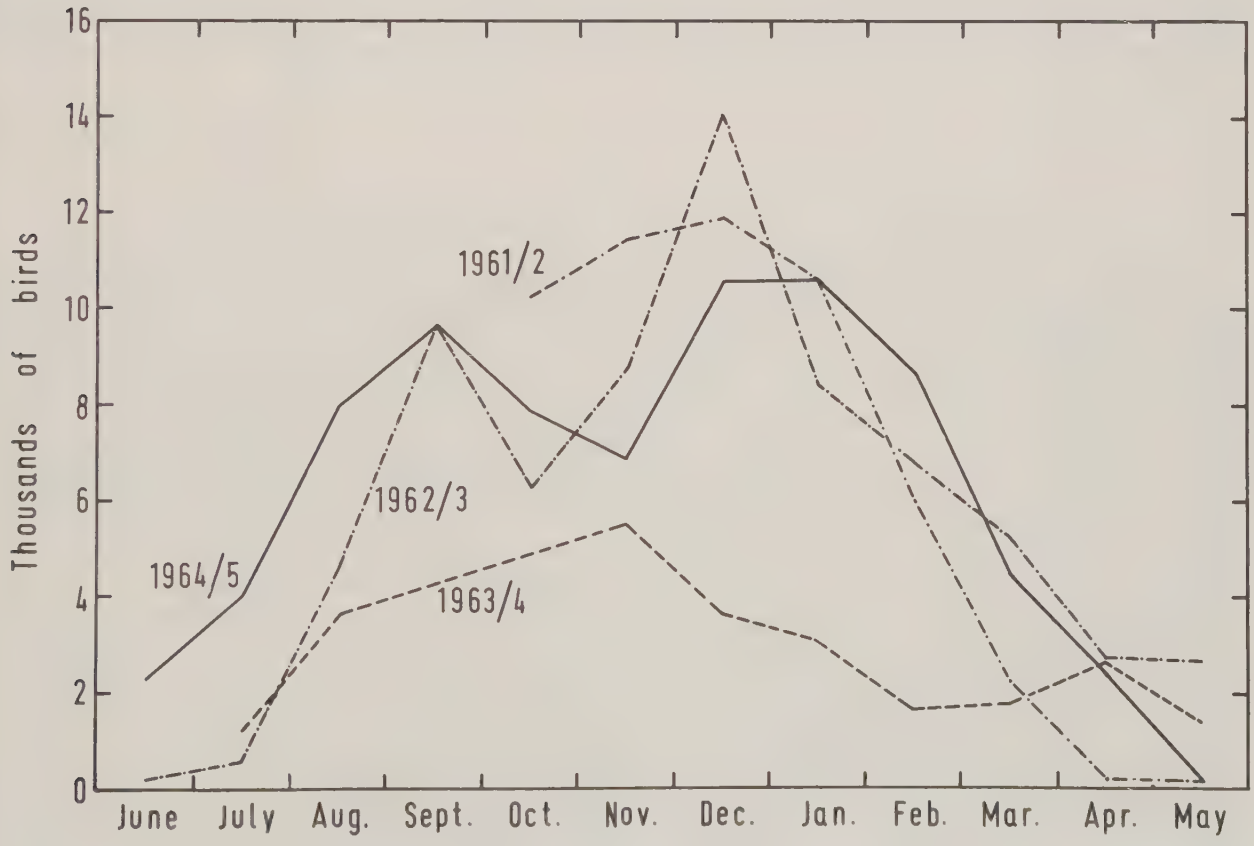

Fig. 3. *Monthly counts of Oystercatchers feeding on cockles in the Burry Inlet*

The pattern of seasonal rise and fall in the population numbers is fairly constant from year to year. There is typically a small summering flock in the Burry Inlet, consisting of up to 2 500 immature birds. (The low counts of birds during the summer of 1962 seem to have been exceptional, according to our observations and those of local ornithologists.) Towards the middle of August the summering flocks are enlarged by the first of the migrants from the northern breeding grounds. These are mainly first-winter birds which precede the main adult breeding population, although adults which breed early or fail to breed also arrive in the Inlet at this time. The brief appearance of groups of very brown young birds in the flocks is at times very noticeable. The flock counts made in the area gave as high as 7·6% of these first-year birds, compared with only about 3% in the wintering flocks (Table 2). This high proportion of young birds is only transitory, a fact which can be explained by two events, firstly the arrival of the main adult breeding population, which swamps the relatively small number of young birds, and secondly the passage onward of the young birds to wintering grounds further south. Both Buxton (1957) and Dare (in preparation) have shown that many of the young British-bred birds spend their first winter in France and the Iberian Peninsula. Chicks ringed in Norfolk have been recovered as far south as Morocco during the winter after ringing.

The breeding adults begin to arrive in August, and in the following month or six weeks the flocks build up to a first peak which then declines again until mid-October. This is the peak migration period and the reduction in numbers probably results from some of the birds dispersing to other wintering grounds.

From mid-October onwards there is a further build-up of numbers to a maximum in late December and early January. A decline in numbers starts in mid-January as the adult birds move off to their breeding grounds further north. Night migrations of Oystercatchers moving inland have been recorded as early as the first week of February, these observations being consistent with the observed arrival of the first birds on breeding grounds in northern Britain in late January and early February (Dare and Mercer, personal communication).

RINGING RETURNS AND RECAPTURE DETAILS

Since November 1962, 797 Oystercatchers caught with cannon nets have been ringed with the British Trust for Ornithology's rings in the Burry Inlet; of these 292 have also been marked with colour bands. No recoveries, either visual or actual, have been made south of the ringing area even though 370 of the birds were ringed during the southward "passage peak" of August and September. Of 15 recoveries of dead ringed birds during the winter months, 7 have been made within 3 miles of the place of ringing, 3 during the first winter following ringing, and 4 during the second. Of these 4 second-winter recoveries 3 were adult birds when ringed, so they had most probably journeyed north to the breeding grounds, while the other bird was still immature when recovered and may not have left the area at all after release. Three others taken from along the South Wales coast at Amroth, 18 miles, Cardiff, 50 miles, and Chepstow, 62 miles away, were recovered 8, 3 and 4 months respectively after release.

There have been 8 recoveries of Burry-ringed birds outside the inlet during the winter months. Bird *AT* 96314 (see Table 5) was unusual in that it was recovered much further north than expected at a period of minimum movement, but this occurred during the very severe winter of 1962/63 when movements were seriously disrupted on account of the substantial reduction of shellfish numbers and hence of the birds' food supply. The other 7 are not considered unusual since our observations show that, although the main migration periods are August/September and February/March, there are only a few weeks (from late November to mid-January) when practically no movement appears to occur. These 7 birds would therefore probably have been late southbound or early northbound migrants; one of them

(*SS* 01374) was reported as having been "dead a long time" according to the finder and it may actually have died during the preceding breeding season.

Four recoveries of Burry Inlet birds have been made on the west coast of England and Wales during passage periods and a further 17 between April and August from actual or potential breeding grounds.

Table 3. *Numbers of Oystercatchers ringed in the Burry Inlet*

Date	Number colour-banded and ringed	Number ringed only
11 November (1962)		386
20 August (1963)	2	
5 September (1963)	204	119
2 November (1963)	31	
30 November (1963)	2	
25 August (1964)	53	
Totals	292	505
Grand total ringed and colour-banded	797	

Table 4. *Details of Oystercatchers ringed, recaptured and re-released in the Burry Inlet*

Ring number	Date of ringing	Age when ringed	Date retrapped	Age when retrapped
308.7903	11 November 1962	Ad.	5 September 1963	Ad.
7930	,,	Ad.	,,	Ad.
392.797	,,	Ad.	,,	Ad.
836	,,	Imm.	,,	Ad.
857	,,	Imm.	,,	Ad.
871	,,	Imm.	,,	Ad.
881	,,	Ad.	,,	Ad.
897	,,	Imm.	,,	Ad.
898	,,	Ad.	,,	Ad.
AT. 96.002	,,	Ad.	,,	Ad.
291	,,	Imm.	,,	Imm.
304	,,	Ad.	2 November 1963	Ad.
343	,,	Imm.	5 September 1963	Ad.
344	,,	Imm.	,,	Ad.
487	,,	Ad.	2 November 1963	Ad.
462	5 September 1963	Ad.	20 November 1964	Ad.
491	,,	Ad.	2 November 1963	Ad.

Ad. =Adult. Imm.=2nd- and 3rd-winter, immature birds.

Table 5. *Recovery details of Oystercatchers ringed in the Burry Inlet*

Date of ringing and number ringed	Ring number	Age when ringed	Date of recovery	Place of recovery	Movement	
					direction	distance (km) (miles)
11 November 1962 (386)	308.7956	Ad.	17 November 1962	*Local*		—
	301.9803	Ad.	12 April 1963	S.W. Iceland	NW	2 560 1 600
	308.7910	Ad.	18 June 1963	S. Uist, Outer Hebrides	NNW	640 400
	AT.96269	Ad.	10 August 1963	King Edward, Banff	N	664 415
	AT.96002	Ad.	5 September 1963 }	Local*		
			4 November 1963 }	*Local*		—
	AT.96314	Ad.	5 January 1964	*Fleetwood, Lancs.*	NNE	264 165
	AT.96005	Ad.	8 January 1964	*Local*		—
	AT.96340	Imm.	15 March 1964	Seascale, Cumberland	N	304 190
	AT.96332	Ad.	30 July 1964	Loch Tay, Perth	N	536 335
	392.787	Imm.	18 August 1964	Annan, Dumfries	N	376 235
	392.877	Imm.	10 September 1964	*Red Wharf Bay, Anglesey*	N	184 115
	392.872	Ad.	7 July 1965	Bour Vagar, Faroes	N	1 760 1 100
	AT.96045	Ad.	23 July 1965	Midvagur Vagar, Faroes	N	1 760 1 100
	301.9834	Ad.	23 August 1965	Stalmine, Fleetwood	NNE	264 165
	AT.96301	Ad.	2 September 1965	*Pentraeth, Anglesey*	N	184 115
5 September 1963 (323)	AT.96362	Imm.	7 September 1963	*Local*		—
	AT.96407	Ad.	29 December 1963	*Local*		—
	SS.01357	Ad.	30 December 1963	*Cardiff, Glam.*	E	80 50
	SS.01463	Imm.	3 January 1964	*Chepstow, Mon.*	E	99 62
	AT.96422	Imm.	19 March 1964	Local		—
	AT.96405	Imm. 1st	27 March 1964	Local		—
	SS.01383	Ad.	21 April 1964	Forglen, Banff	N	664 415
	AT.96354	Imm.	25 May 1964	Amroth, Pembs.	W	29 18
	SS.01369	Ad.	— June 1964	Gutcher, Yell, Shetland	N	1 024 640
	AT.96406	Ad.	30 June 1964	Drumoak, Aberdeen	N	608 380
	AT.96375	Ad.	20 July 1964	N. Uist, Outer Hebrides	N	680 425
	SS.01493	Imm.	— August 1964	North Berwick, E. Lothian	N	496 310
	AT.96436	Ad.	18 August 1964	Ythan Wells, Aberdeen	N	648 405
	SS.01332	Ad.	28 August 1964	Valley, Anglesey	N	184 115
	SS.01374	Ad.	3 February 1965	*Ardgay, Ross*	N	680 425
	AT.96454	Imm.	18 February 1965	*Local*		—
2 November 1963 (31)	AT.78337	Ad.	28 February 1964	*Belfast Lough, Co. Down*	NNW	354 220
	AT.78350	Imm.	22 October 1964 }	*Gronant, Flints.**		—
			15 August 1965 }	Eastriggs, Annan	NNE	386 240

Italicized recoveries treated as winter recoveries in text
*—Controlled (retrapped and released alive)
Imm. =2nd-and 3rd-winter. immature birds
Imm. 1st =1st-winter. immature birds
Ad. =Adult

There have been few records of birds ringed in winter away from the South Wales coast subsequently being seen in the Burry Inlet, and none has been recovered there. During the years 1962-65, 4 659 Oystercatchers have been ringed by the Ministry of Agriculture, Fisheries and Food and Liverpool University teams on the west coast of England and Wales outside the Burry Inlet and 3 979 of these have also been colour-banded. The colour-band sightings are dealt with in the next section of this paper.

Many birds ringed in the Burry Inlet during the winter months have subsequently been recaptured in cannon nets at the place of ringing (Table 4). Of 386 birds ringed at the Whiteford roost in November 1962, 14 were recaptured at the same place on 5 September 1963. All but one of these were in adult plumage and it can be assumed that they had been away from the Inlet to breed during the summer of 1963, since there is only a very small local breeding population during the summer months (ca. 5 pairs).

The total catch by the cannon nets on 5 September 1963 was 750, so the 14 ringed birds formed 1·9% of the catch. The birds appear to mix randomly at the roost, and the flock present that day consisted of practically all the birds present in the Inlet, so it can be assumed that this percentage of ringed birds would hold for the total flocks of 9 500 birds present at that time (eye estimate), giving a total ringed of 9 500 × 1·9/100 = 180. Thus 180 of a total of 386 birds ringed in the winter of 1962 had by September 1963 already returned to their wintering grounds. That these birds remained in the Burry Inlet during the winter and were not passage birds will be shown in the section on colour-banding.

OBSERVATIONS ON COLOUR-BANDED BIRDS

In order to be able to observe birds of known origins during the winter periods, the majority of those birds caught in the Burry Inlet by cannon nets were marked with coloured leg bands. Yellow polyvinyl chloride bands were used to mark the birds caught in autumn and winter 1963, and two bands, one yellow and one orange, were used for those caught in autumn 1964 (see Table 3). The failure to make another capture during the winter of 1964/65 and the consequent small sample marked in that period has reduced the value of the observations subsequently made of those birds, so in calculations of return rates (see below) only birds marked in 1963 are considered.

On four occasions during each of the winters 1964/65 and 1965/66 counts of colour-banded birds and non-colour-banded birds were made in the Burry Inlet. From a parked vehicle the feeding birds were scanned through binoculars, and only birds with both legs clearly visible were included. The counts were carried out wherever the flocks could be approached closely enough and not from any set point. The details of the individual sub-samples are given in Table 6; from these figures the totals of colour-banded birds observed are expressed as percentages of the whole samples. Assuming these percentages to be representative of the whole Oystercatcher population in the Inlet an estimate of the total numbers of colour-banded birds present on each occasion can be made. Unfortunately no confidence limits can be set on these figures, because variation between the individual sub-samples is so great that the distribution of the banded birds in the flocks appears to be non-random. However, the samples were taken throughout the whole length of the Inlet and on two of the occasions comprised about 25% of the total birds present. The estimates of the number of colour-bands is therefore probably realistic. The population count figures given in Table 6 do not include the birds feeding on the Whiteford mussel scars, although occasional observations carried out there revealed the presence of colour-banded birds. The scars are very uneven which makes accurate counts extremely difficult, but a flock estimated at between 1 000 and 1 500 birds was present during these observations.

When expressing the numbers of colour-banded birds present as a percentage of the original 239 birds marked in 1963, no allowance is made for annual mortality. This has been variously calculated as 7·5% (Grosskopf 1964) for the adult birds breeding in a north German reserve, and as around 30% (Boyd 1962) from the recoveries of British-ringed birds. The latter figure is inapplicable to this study

Table 6. *Samples showing numbers of colour-banded and non-colour-banded Oystercatchers in the wintering flocks*

	Winter 1964/65								Winter 1965/66							
	18 December 1964		2 January 1965		17 February 1965		18 March 1965		9 September 1965		5 October 1965		15 November 1965		20 January 1966	
	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd	No. banded	No. exam'd
	2	171	2	210	1	95	0	60	0	105	3	100	0	60	2	210
	4	230	0	128	0	93	0	161	0	108	2	320	0	300	1	190
	0	130	5	271	2	70	0	108	3	146	3	160	0	210	1	70
	3	127	3	277	0	83	0	40	2	90	1	25	4	135	1	130
	1	80	3	160	1	120	1	109	3	100	1	120	1	85	1	71
	6	185	1	204	2	153	0	60	2	215			1	168	0	110
			1	185	5	300	1	132	3	128					1	25
			5	321	2	223	0	104	7	182					2	310
							5	70	1	50					0	230
							3	71	2	184					3	385
							2	76	1	110					2	193
							4	243							0	80
							3	111							0	310
							1	74							0	94
							1	38								
Totals	16	923	20	1 756	12	1 137	21	1 457	24	1 418	10	725	6	858	14	2 408
Percentage of banded birds seen	1·73		1·14		1·06		1·44		1·70		1·38		0·70		0·58	
Population count	10 500		10 500		8 600		4 500		9 600		9 000		15 800		11 600	
Estimated total of banded birds in population	182		120		90		65		163		124		111		67	
Percentage of banded birds returned	76		50		37		27		68		52		46		28	

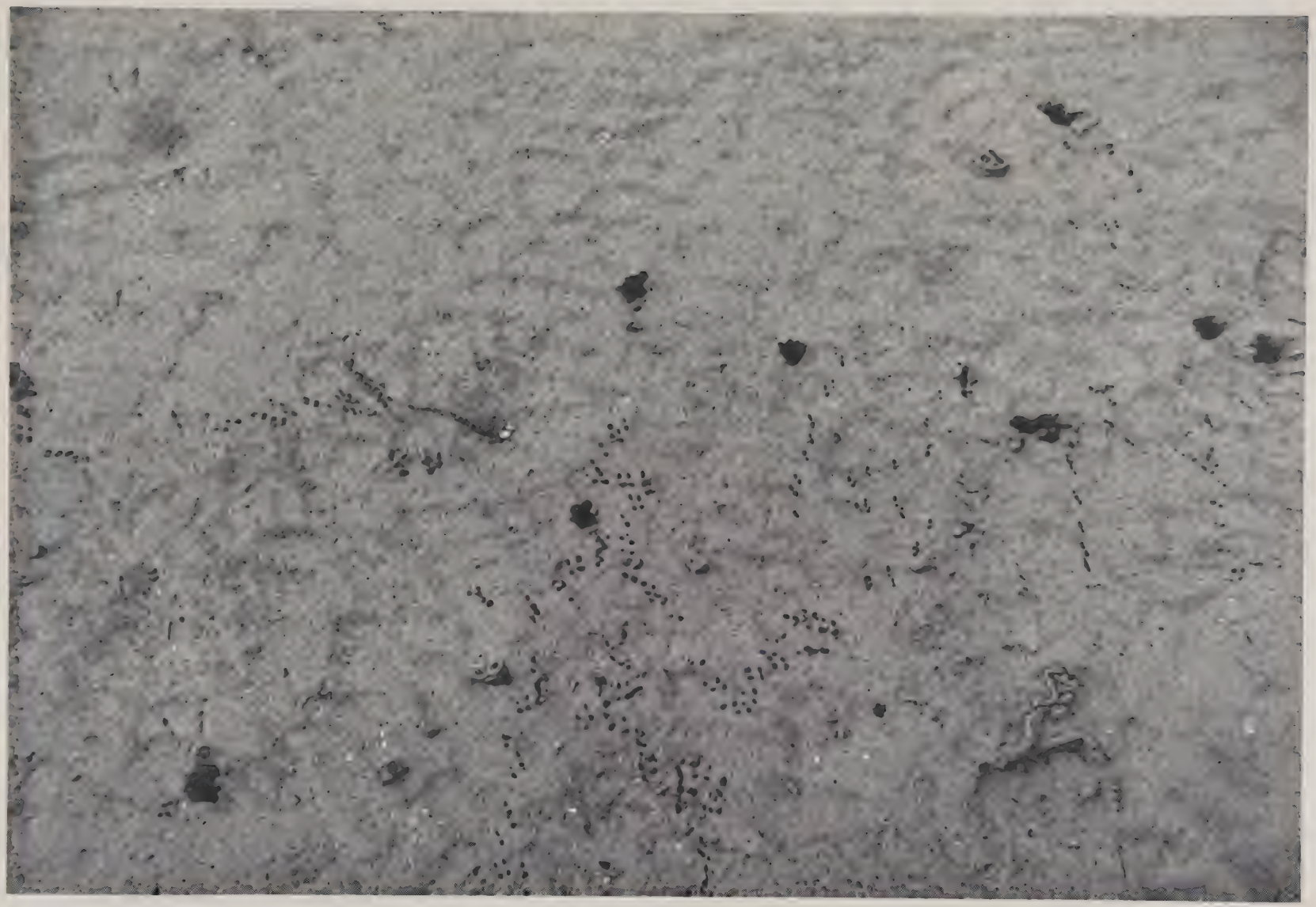

PLATE 1. *Probe holes left by the open beak of an Oystercatcher over an area densely populated with young cockles. Larger holes indicate the selective removal of some of the few individuals entering their second winter* (*August* 1961)

PLATE 2. *Typical heaps of broken shells left by Oystercatchers*

PLATE 3 *Close-up views of feeding piles left by Oystercatchers, showing opened and broken cockle shells*

PLATE 4. *Close-up views of feeding piles left by Oystercatchers, showing opened and broken cockle shells*

since it includes data from many birds ringed as chicks, among which it is known that the mortality rate is very high. The birds marked for this study were predominantly adult (ca. 75%) with a very small percentage (ca. 5%) of first-year birds.

A further point which gives support to these estimates of percentage returns of colour-banded birds is the scarcity of records of them in other areas. All the major wintering areas of the Oystercatcher on the west coast of England and Wales have been regularly visited, and apart from the Taf-Towy estuary no regular sightings have been made. The scattered birds found round the south-west coast of Wales total less than a thousand and only one colour-band sighting has been made in this area, despite two careful checks by the Ministry team and occasional checks by local observers.

When the numbers of colour-banded birds are plotted against time (Figure 4) it is seen that both in 1964/65 and 1965/66 there was a steady reduction in numbers throughout the winter, and it is most probable that if observations had been made in September 1964 about 90% of the birds banded the year before would have been found in the Inlet. In September 1965 the number returning had only fallen to just below 70%.

It would thus appear that a large proportion of the birds present in September 1963 at the time of colour-banding returned in September 1964 and again in September 1965, for these figures do not take mortality into account. The most likely explanation of the fall in numbers during the winter is a dispersal along the neighbouring coastline prior to a return to breeding grounds after February.

Very few birds colour-banded in other areas are seen in the Burry Inlet during the winter months. A typical example of this can be seen in the survey carried out there on 17 and 18 February 1965. The

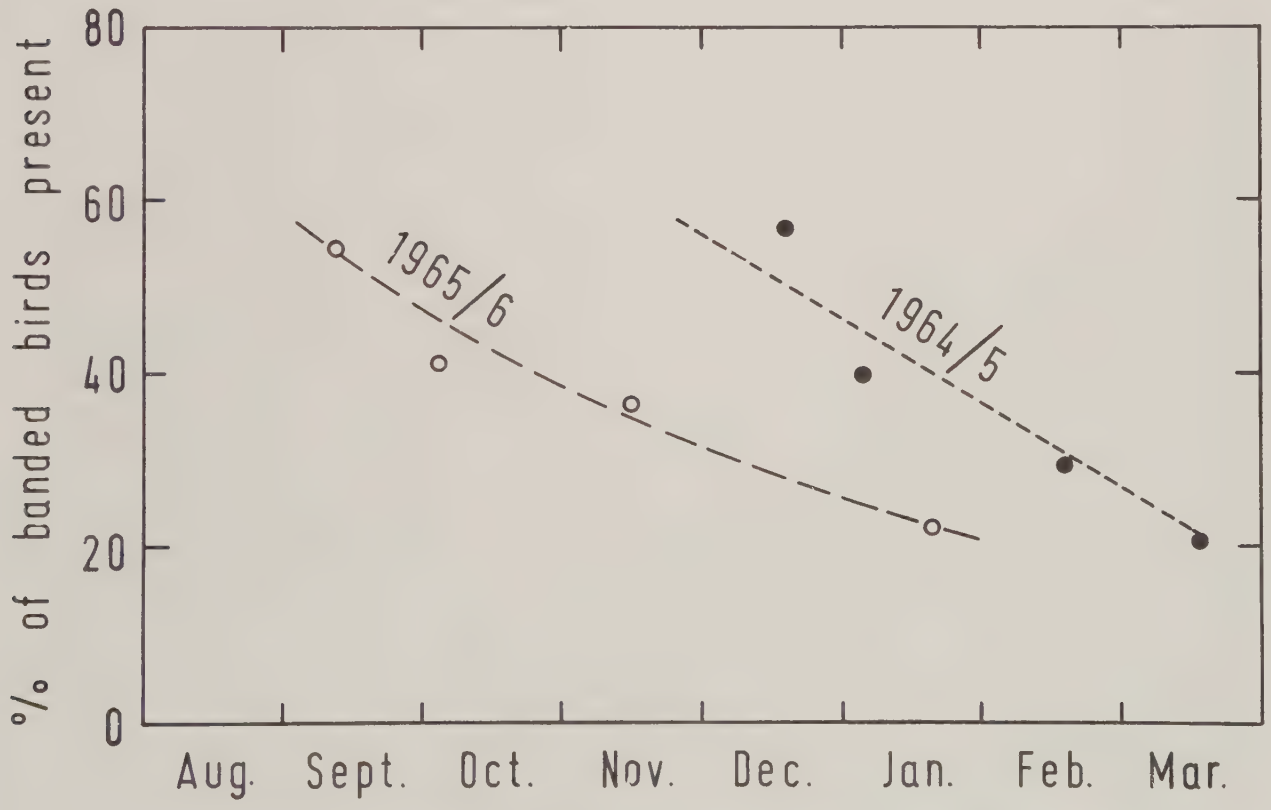

Fig. 4. *The decline in numbers of colour-banded Oystercatchers in the Burry Inlet during the winter months*

numbers of banded birds seen and the total originally banded in each of the areas are given in the following table:

Where banded	Numbers banded*	Numbers seen in Burry Inlet 17-18 February 1965
Burry Inlet	292	52
Morecambe Bay	874	1
Llanfairfechan	277	1
Dee (Cheshire)	ca. 2 400	1

* By M.A.F.F. and Liverpool University teams, 1962–64

Despite widespread surveys during the winters of 1963/64 and 1964/65, only 9 sightings of Burry Inlet colour-banded birds were made outside the Inlet and of these, 6 were in temporary flocks during known passage periods, 2 at Barmouth and 4 in Red Wharf Bay, Anglesey.

SUMMARY OF RINGING RESULTS AND COLOUR-BANDING OBSERVATIONS

During the years 1963-64, 797 birds have been ringed in the Burry Inlet, 378 of them in the period of maximum migration movement, viz. August and September. None of these birds has been recovered or sighted south of the area of ringing, indicating that most of the birds present in the Inlet in the early autumn probably stayed there and did not move south, although some movement out of the Inlet is indicated by the fall-off in numbers from September to October. This may be due to local dispersion along the coast. All but one of the winter recoveries north of the Inlet have been made during known passage periods and on possible routes to and from the Inlet.

Colour-band observations made during the months of September to February suggest that, although the majority of the wintering birds are adult (at least 75%) and these move away from the Inlet during the summer months to breed, a large proportion of them return year after year to the area to winter there; they arrive early in the autumn, and the majority stay until the early months of the following year.

Very few Burry Inlet-banded birds have been seen outside the area of ringing during the winter months.

The build-up in numbers of birds in any area can be the result either of the passage through that area of large flocks of birds, with the peak numbers occurring at the times of peak movement through the area, or of the entry of a relatively few birds into the area to join large resident flocks during the passage peak periods or the colder midwinter months. Observations of Oystercatchers in the Burry Inlet tend to support the latter explanation of the changes in the population numbers.

When our recoveries are compared with the results from similar studies in the Welsh Dee Estuary (White 1964), from which Oystercatchers are known to scatter in the winter as far south as the Exe estuary in Devon and as far north as the Solway Firth, it would appear that the South Wales population is remarkably discrete during the winter months.

The Burry Inlet is the main centre of the population, with the Taf-Towy estuary varying in importance from year to year. Swansea Bay may hold around 200 birds, and the rest of the South Wales coast has only scattered groups totalling probably not more than 600–1 000 birds.

FOOD AND FEEDING

THE range of food species available in quantity to the Oystercatcher in the Burry Inlet is not great. Towards the eastern end of the beds (Cefn area) there was until the severe winter of 1962/63 a fairly extensive bed of *Scrobicularia plana*, whilst *Macoma balthica* occurs in moderate numbers in most areas (Hancock and Urquhart, in press). Mussels (*Mytilus edulis*) are found along the training wall (Figure 2) and on the shingle spit off Whiteford Point, as well as in patches ("crumbles") on the sand flats where the young mussels attach themselves to old cockle shells. During the summer months large numbers of small crustacea are to be found, e.g. *Corophium* and *Bathyporeia*. Polychaete worms (mainly *Arenicola marina*) are common in most areas, but where there are molluscs to be found the worms are seldom eaten (see also Hulscher 1964). Birds feeding in fields surrounding the Inlet undoubtedly take many terrestrial species, such as beetles and earthworms, but as these birds are few in number and as, in any case, they are not included in the counts, their effect upon the final calculations can be ignored.

By far the most numerous mollusc in the Inlet is the cockle (*Cardium edule*) with densities ranging from several thousand per square metre on the commercial beds to a scattered few extending into the *Spartina* zone at the top of the beach. The spat cockles may settle in dense beds of up to 17 000 per square metre (Hancock and Urquhart, in preparation).

Detailed evidence of the extent to which Oystercatchers feed on cockles has been obtained from three separate sources: (a) direct observation of feeding birds, (b) examination of shell piles, and (c) analysis of gut contents.

DIRECT OBSERVATIONS OF FEEDING BIRDS

Drinnan (1957) described in detail the feeding behaviour of the Oystercatcher on cockles and our observations in the main support his findings, with a few small differences associated with local variations in density and size of cockles and conditions of substrate. Observations on birds feeding on cockles were made through either $\times 10$ binoculars or a $\times 60$ telescope. On one occasion during a period of observation in April 1964 the birds were watched for over half-an-hour, feeding to within 25 m of the observer. The sands in this area were dry, and conditions were such that, according to Drinnan's observations, one would have expected the random probing/search behaviour. The birds were, in fact, finding cockles at every second or third probe. In a check of the success rate of random probing in this fairly thin bed of cockles, 300 probes were made at random with a wide-bladed sheath-knife; only 10 cockles were located, yet from observations of the birds it had been established that it would have taken them only 20–30 probes to find this number. On careful scrutiny of the sand surface there was no superficial evidence of the presence of buried shellfish; the actual means employed by the birds to find the cockles is not clear, but some visual or auditory mechanism must have been involved.

In dense beds of brood cockles (those in their first winter and usually measuring between 5 and 15 mm) which contain only a few larger ones, both Hancock and the writer observed beak probe marks (Plate 1). As the birds walked forward the mandibles were seen to be held slightly open and rapid pecking movements were made. The searching probe with the mandibles open is reported by Hulscher (1964), who also calculated that the success rate of the Oystercatchers' search for cockles was greater than would be achieved by chance. His calculations were based upon the relative surface area of cockle and bill tip, and the proportion of the sand occupied by the shellfish.

EXAMINATION OF FEEDING PILES

When feeding on cockles, Oystercatchers make use of any firm patches in the sand to open the shells. Having picked up a cockle the bird may run several yards, presumably to a firmer area, before placing it edgeways on the sand and opening it with a sharp thrust of the bill and a sideways twist of the head. This method of opening the cockle usually results in a breaking of the anterior portion of the right valve of the shell. When several birds have used the same area for opening cockles for some time the broken shells become buried in the sand and enhance the firm nature of the patch, which attracts more birds to open shells there. Eventually shell-piles about a metre in diameter may be built up every three or four metres across the sand (see Plate 2). These piles may persist in an area with little tidal scour and eventually rise two or three centimetres above the general level of the sand surface, with shell worked down a further four or five centimetres into the sand.

Examination of these feeding piles in the Burry Inlet revealed the original cockles over which the piles were built, rejected cockles brought to the piles by the birds and left unopened, and the opened shells with the characteristic fracture of the right valve (see Plates 3 and 4). No open shells other than cockles were found when the piles occurred in areas of abundant *Macoma*. Evidence that these piles aid in the opening of cockles by Oystercatchers is presented later in this paper.

ANALYSIS OF GUT CONTENTS

Examination of the gut contents of birds shot while feeding on the cockle beds has shown that their diet consists almost entirely of cockles. The yellow foot of the shellfish is the most persistent and easily identifiable structure. Counts of these feet among the contents of the gizzard, crop and oesophagus provide an indication of minimum numbers eaten; as many as 140 have been found in the crop of a shot bird. Birds shot on the roosts have usually been driven from the feeding grounds by the tide at least two hours previously, and their gut contents are therefore unidentifiable. Our observations agree with those of Drinnan (1957) who stated that the cockles are digested to a state beyond recognition in about two hours.

Four feeding birds shot on 18 February 1965 at various periods after high water contained the following numbers of cockles:

4½	hours	after	H.W.	—	maximum	1½	hours	feeding	72	cockles
6½	,,	,,	,,	—	over	2	,,	,,	95	,,
7½	,,	,,	,,	—	,,	2	,,	,,	110	,,
8½	,,	,,	,,	—	,,	2	,,	,,	80	,,

The last 3 birds all had unidentifiable remains as well as fresh and part-digested cockles in their gizzards. Although it is impossible to say exactly the size of cockles on which these birds had been feeding, the size of the undigested food indicated that the majority of the remains were those of second-winter cockles.

THE SIZES OF COCKLES EATEN

In years when commercial-sized cockles older than first-winter are in good supply there is little evidence of the birds feeding on the newly settled spat, but in the winter of 1963-64, when older cockles were scarce, many birds were observed to be feeding almost entirely on spat. On occasions, areas were found where Oystercatcher bill-probe marks were as numerous as 100 per square metre, many of these probe marks containing at the base of the hole a smashed spat cockle shell with fresh shreds of flesh, indicating that it

had been opened during that tide (see also Hancock and Urquhart 1965). Prior to 1963/64 only once was a bird seen by the writer to be feeding on spat cockles, and on that occasion 20 cockles of about 10 mm shell length were taken in five minutes. Here the bird was feeding in an area of soft muddy sand and was extracting the cockles from the substrate before opening them; it did not smash the shell while the cockle was still buried, as in the case reported above.

Second-winter cockles are normally the most numerous year-group apart from the spat, and form the bulk of the fishery stocks, for it is during its second year that the cockle grows to the minimum legal size imposed by the South Wales Sea Fisheries Committee. At the present time (1965-66) no cockle may be taken if it will pass through a square gauge having a side of $\frac{3}{4}$ inch (19 mm), which is equivalent to a shell length of about 23 mm (Hancock 1963). Annual mortality is fairly high, so few cockles grow to the size (30-35 mm) at which the shell is resistant to the attack of an Oystercatcher.

The fishermen state that the birds will come and take cockles which have been left on the surface during fishing. These would be ones which, being under the legal minimum size, had fallen through the riddles used by the fishermen.

A comparison in March 1961 between the length of shells found on the feeding piles and those of the live cockles buried in the neighbouring sands showed no size selection by the birds amongst second-winter cockles (see Figure 5). No opened spat shells were found among the shells of second-winter cockles on the feeding piles even when these were surrounded by dense areas of spat. No feeding piles were found in the areas where the birds were taking spat cockles. The feeding piles examined in the spring of 1961 were from four widely separated areas of heavy predation. In these samples there were too few cockles older than second-winter to show any evidence of preferential selection of second-winter cockles. However, Hancock and Urquhart (1965) have clearly shown that even when there are many cockles older than second-winter in the beds there will be a positive selection in favour of the second-winter cockles (see table below):

Observations in January 1962

	First-winter	Second-winter	Older
Numbers in sample from feeding piles:			
Living—rejected by the birds	2	4	9
Dead —opened shells	0	71	3
Numbers living in sand (no. per m^2)	6 070	29	40

It can be seen that the 4:3 ratio of the older cockles to second-winter cockles living in the sand is reversed to a 24:1 ratio in favour of second-winter cockles among those eaten.

In late February 1964, selection of certain sizes of second-winter cockles was revealed by the examination and comparison of shells found open and unopened on the beach where a small group of birds was feeding without using nearby feeding piles (Figure 6). Through binoculars, it was possible to see that the birds were walking forward probing every few steps. On contacting a cockle a bird would lift it out of the sand and carry it a few paces, after which the cockle would either be placed on its edge and opened, or rejected after a few brief pecks at the shell and ignored both by the finder and subsequently by other birds feeding in the area. These rejected cockles, all of the second-winter group, were collected and measured, as were the opened shells, also of second-winter cockles. The path taken by the birds and afterwards strewn with cockles and empty shells will be referred to as the "feeding trail".

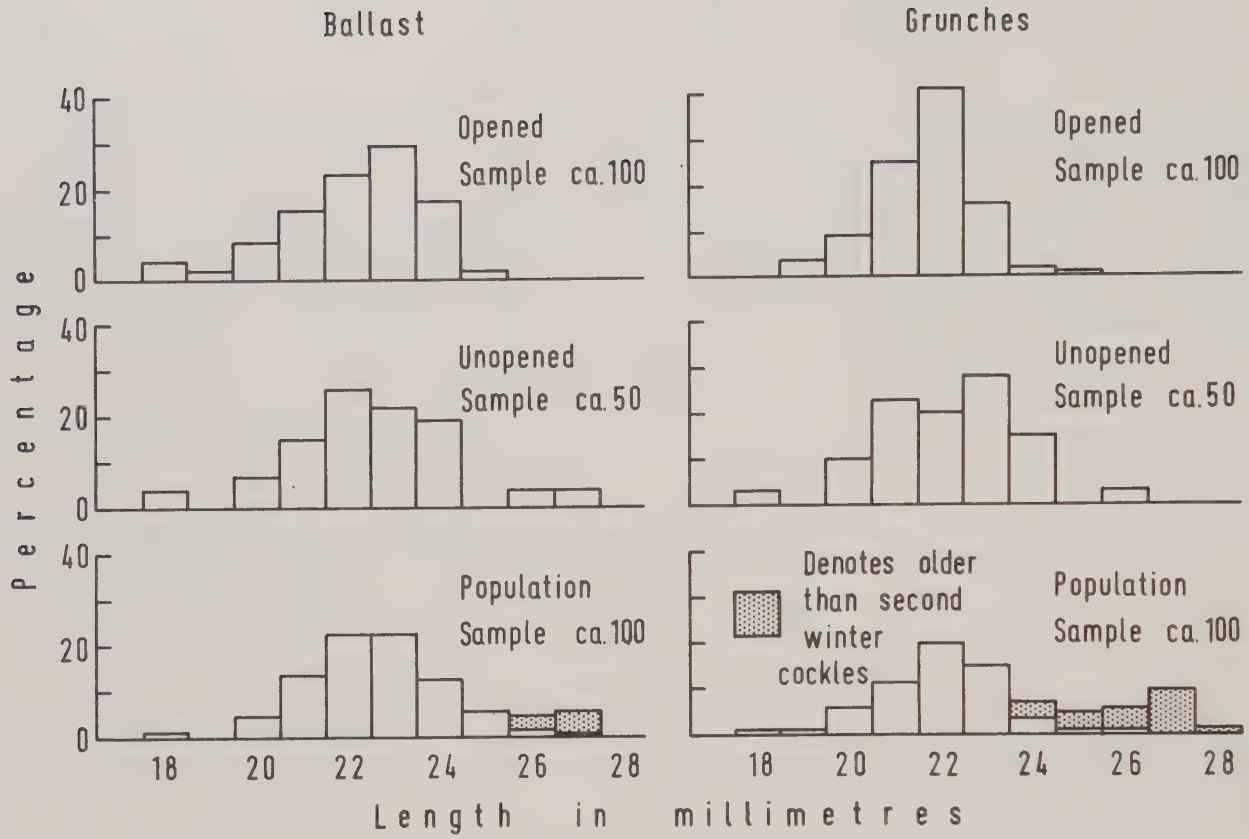

Fig. 5. *Size distributions of opened and unopened cockles taken from a feeding pile, compared with samples from the surrounding population, showing no size selection by Oystercatchers among the second-winter cockles* (10 *March* 1961)

Opened cockle shells from the feeding trail were significantly smaller (at the 0·1% level) than rejected cockles, indicating a degree of selection by the Oystercatcher after the cockles had been removed, presumably randomly, from the sand. No significant difference was shown between the rejected cockles and opened shells of second-winter cockles taken from a nearby feeding pile. This would suggest that, although there may still be some selection before the cockles are brought to the feeding pile, the largest ones being rejected, the birds benefit by using feeding piles because the firmer substrate enables them to open slightly larger cockles.

Newly opened shells of cockles larger than second-winter are sometimes found scattered over the sand. These are probably opened by the birds before the receding tide has uncovered them completely. The slight gape of the shell when the syphons are protruded enables the bird to gain entry into the cockle (see also Drinnan 1957). Larger cockles are also taken in conditions of extreme cold, as in the 1962/63 winter when, due to freezing, they become moribund and gape a little.

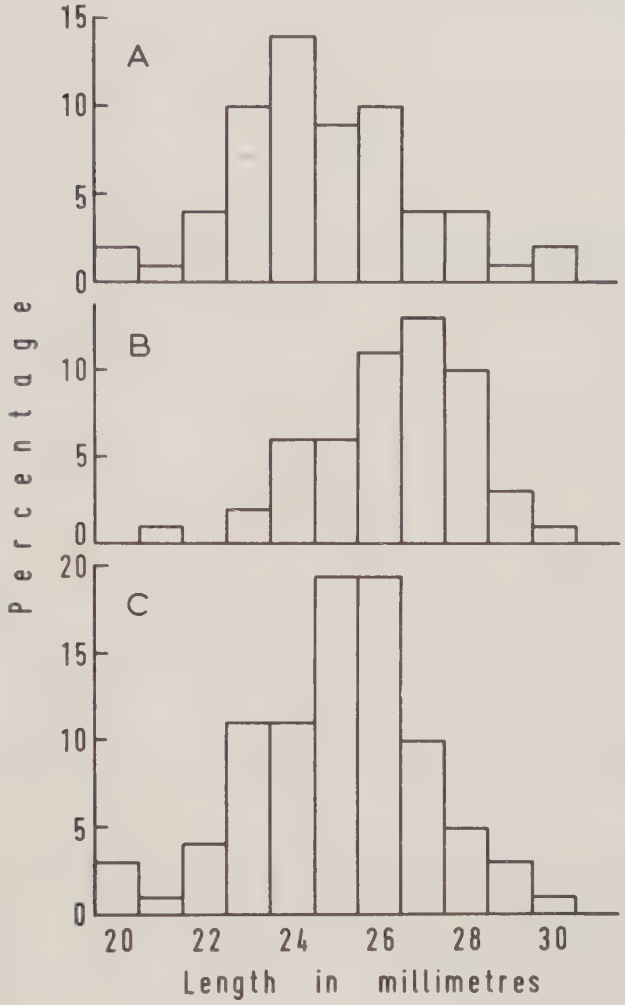

Fig. 6. *Size distribution of cockles* (26 *February* 1964)

A. Opened cockles from the feeding trail

B. Unopened cockles from the feeding trail

C. Opened cockles from the feeding pile

A and B are significantly different at the 0·001 *level;*

C does not differ significantly from either of the other two

Table 7. *Feeding rates (as cockles per minute) and details of predated cockles, taken from observations of feeding Oystercatchers*

Date	Observed feeding rate	Average number of cockles eaten per minute	Modal size (mm) of cockles eaten	Meat weight (g) of modal size	Meat volume (ml) of modal size
7 March 1961	35 cockles in 34 minutes	1·03	21	0·69	0·66
22 November 1961	30 cockles in 30 minutes	1·0	21	0·72	0·70
23 January 1962	22 cockles in 30 minutes	0·73	22·8	0·73	X
23 January 1962	69 cockles in 21·5 minutes	X	10·15 (spat)	X	X
22 February 1962	29 cockles in 29 minutes	1·0	19·1	0·57	X
18 February 1965	42 cockles in 20 minutes	2·1	18	0·31	0·4
19 February 1965	37 cockles in 19 minutes	1·9	20	0·52	0·66
19 March 1965	37 cockles in 42 minutes	0·88	23	0·96	0·85

X indicates that no reliable data are available

FEEDING RATES

METHODS AND OBSERVATIONS

An important part of these investigations has been to determine the quantity of cockles destroyed by the Oystercatcher, and to do this information was required on the numbers of cockles consumed per bird per day. The methods used were those developed by Drinnan (1957) in which the numbers of cockles consumed per unit time during feeding were combined with data on the proportion of the birds feeding during each hour when cockles were exposed by the tide, or conversely on the proportion of the available period when the beds were exposed spent by each bird in feeding.

Birds were watched through binoculars or a telescope for periods of five minutes, or until they ceased feeding, and counts were made of the number of cockles seen to be taken during this period. Only cockles seen actually to be opened were recorded as eaten, for often a bird would select a cockle, carry it some distance and then drop it again, leaving it unopened. There have been no observations of birds picking up these abandoned cockles even when the total stocks have been very low and large flocks have been feeding in the area.

Rates at which Oystercatchers were observed to be feeding are given in Table 7; these figures agree well with Drinnan's average rate of one cockle per minute. As shown in the table, rates well in excess of Drinnan's were sometimes recorded but only in areas where birds were feeding on brood cockles or where the meat content of the cockles was very low.

The average shell length of cockles in the Burry Inlet varies from bed to bed but no generally apparent size selection within the second-winter group is shown by the birds, cockles being opened at the feeding piles, or at least taken to some firm area, more often than where they are found, as observed in the feeding trail behaviour.

At any state of the tide, when the cockle beds are exposed, some flocks of Oystercatchers can be seen to be moving around the Inlet. This movement of birds is often associated with the passage of cockle pickers, but at other times seems to be quite spontaneous. These movements suggest that the birds have no particular preference for any one source of second-winter cockles and are assumed to result in random mixing of the birds, although it may still be true that a high density of second-winter cockles does have some attraction.

The next point to be ascertained was the duration of time during which the birds continued to feed. First the time during which the feeding grounds are uncovered by the tide was calculated. The average period between successive high-water times is about 12½ hours, and from personal observations an average tide will begin to uncover the cockle beds at approximately two hours' ebb (Figure 7) (see also Hancock and Urquhart 1966) and will completely cover them again two hours before high water, giving 8½ hours' potential feeding time. Some of the birds will fly to the cockle beds as soon as they are uncovered and the rest will arrive in small groups throughout the next hour. On arriving on the beds the birds commence to feed at a high rate. During the period of feeding observations, the percentage of birds feeding was noted at intervals throughout the tidal cycle. This series was necessarily incomplete, because in order to avoid being cut off by the tide the observers had to leave the beach before the birds were driven off. The fact that the birds are arriving in groups throughout the first hour in which the cockles are uncovered has been taken into consideration in calculating the average feeding rate for that period.

An estimate of the percentage of the low-water period which the birds actually spent feeding was obtained for each of six tidal periods by multiplying the hours between observations by the percentage of birds feeding at the start of each of the periods (Table 8), summing the totals and expressing as a percentage of the available time. The estimate obtained from the first four sets of observations is likely to be too low, because they did not include the period of rapid increase in feeding rate which occurs just before

Table 8. *Changes in feeding intensity throughout the tidal cycle, expressed as the percentage of birds feeding at a given time*

Hours after high water	7 March 1961	22 November 1961	23 January 1962	22 February 1962	18 February 1965	19 March 1965	Hours after high water	Average figures
2							2	
Period during which beds are uncovering	(45)	[95] (47)	[100] 50	[100] (50)	46	(50)	Period during which beds are uncovering	48
3	90				93		3	91
	95	75	100	100	80	100		92
4	55		95	80	72		4	75
	50		75	60	80			63
5	75	60		30			5	
			60					54
					49			
			20					
6				20			6	
			20					21
			25					
7	60	65		20	49		7	48
			25			50		35
			30			30		
8	65	80		40	84		8	67
			60			50		58
						60		
9						80	9	80
						90		90
					96			96
10 Period during which beds are uncovering					(40) [80]	(45)	10 Period during which beds are uncovering	55
Average % of birds feeding	66	68	53	43	64	55		

Figures in square brackets are observations whilst birds are arriving on, and leaving the beds. Estimates of the true percentage feeding are shown in parentheses, and these are used in calculating the average percentage of birds feeding. The beds are exposed for a total period of 8 hours 30 minutes.

the tide covers the beds. The last two sets of observations recorded were made with the aid of a vehicle, so enabling the observers to spend longer on the beach before the tide flooded the beds, and these figures alone include this period of high feeding rate.

A more reliable estimate of feeding time can be obtained by averaging all the observations made at similar tidal times on different occasions and then plotting the result, as in Figure 7. The area under the curve then gives an average figure for the percentage of the available time spent feeding per bird. In this case the figure obtained by calculating the area is 55%, which agrees with the result obtained if the calculation is made by the method of multiplying the period between observations by the initial percentage feeding, and is close to the result obtained (57%) if the average of individual days' observations is taken. The figure of 55% is therefore used in the following calculations.

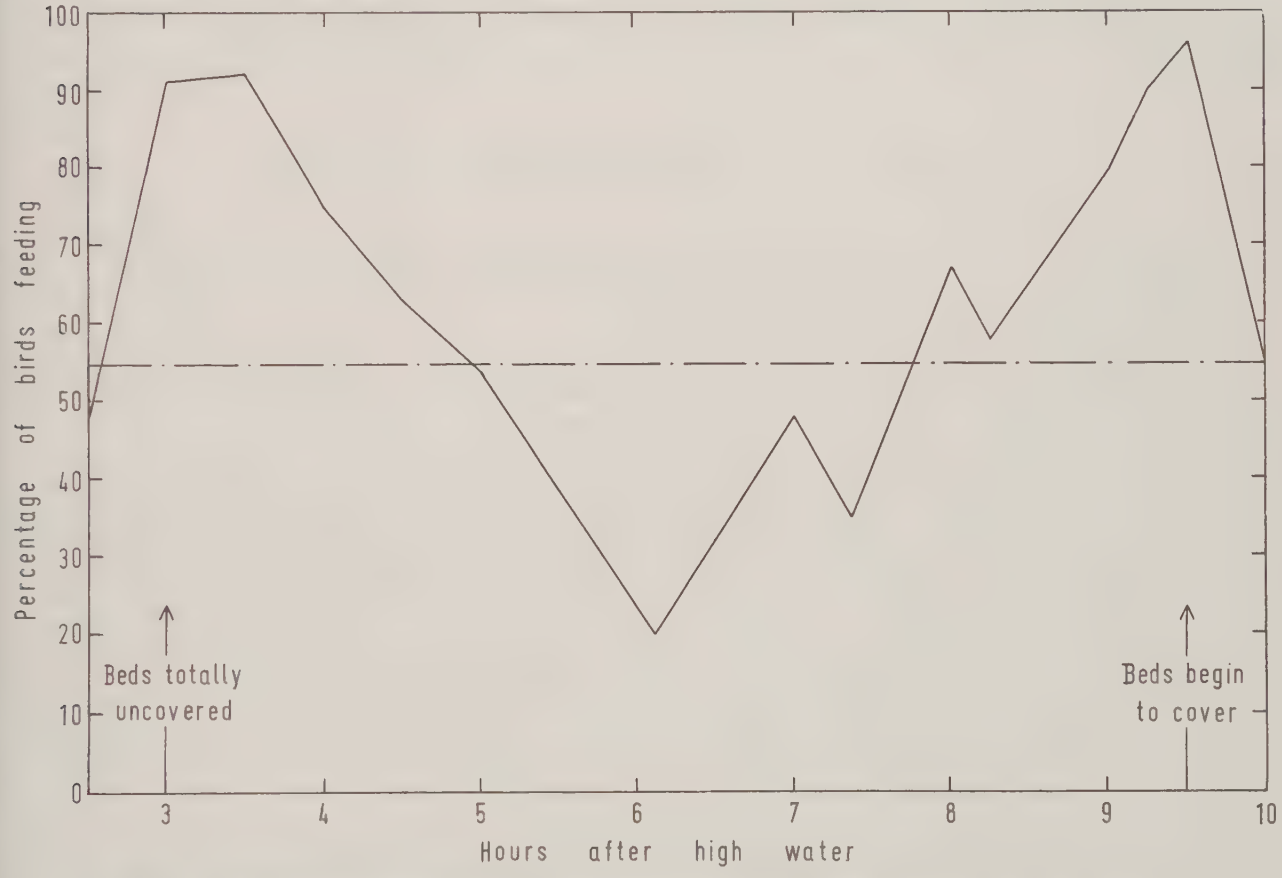

Fig. 7. *The average percentage of Oystercatchers feeding at any stage of the tidal cycle. The 55% is the average feeding rate as calculated from the percentage of the polygon beneath the line. The first and last points plotted are corrected to allow for the birds' arrival on and departure from the beds*

CONSUMPTION OF COCKLES — NUMBERS

During the winter of 1961/62 observations of feeding rates were made every two months. Accordingly, calculations of consumption of cockles by individual birds were made for three periods — October/November, December/January, February/March. During the first observations the birds were feeding at the rate of one cockle per minute for 55% of the 510 available minutes, so each bird took 55% of $510 \times 1 \cdot 0 = 280$ cockles per daylight tide. For the second period the lower feeding rate of 0·73 cockles

per minute (Table 6) was used, giving an offtake of 55% of $510 \times 0 \cdot 73 = 205$ cockles per daylight tide. The last period again gave a figure of 280 cockles per daylight tide.

In February 1965 observations on feeding rates were made at opposite ends of the commercial beds. On the easterly beds the cockles were of ca. 18 mm modal size and the feeding rate was 2·1 per min; on the more westerly beds the cockles were of 20 mm modal size and feeding was at a rate of 1·9 per min (Table 7). Respective observation periods of 42 and 37 minutes in two days were composed of five-minute periods (less if the bird stopped feeding) spread throughout the tidal period.

Using a mean feeding rate, from the two sets of observations, of 2 cockles per min the consumption is calculated as $55\% \times 510 \times 2 = 561$ cockles per bird per tide. This high feeding rate appeared to be related to the poor meat content of the cockles (see Table 7). In the following month the feeding rate observed during 42 minutes of observation was 0·88 per min, the cockle modal size being greater and the meat content better (see Table 7); the consumption was calculated as $55\% \times 510 \times 0 \cdot 88 = 247$ cockles per bird per tide.

CONSUMPTION OF COCKLES — WEIGHTS

The number of cockles eaten by an Oystercatcher if adequate stocks are available will depend upon the food requirements of the bird and the quantity of the meat in the cockles. The quantity of cockles consumed is most easily expressed as wet flesh weight.

Figures for the average length and meat content of the cockles are available for the periods when observations of feeding rate and time spent feeding were made. The figures for March 1961 and 1965 were obtained by the writer, and other figures have been supplied by Hancock (personal communication) from his regular survey observations and calculations of fresh or cooked meat weight.

There are many variables to consider in making the present study and in estimating the intake per bird. The sizes of the individual cockles in any one year-class will vary and the modal size is used in this paper as a convenient compromise, although it is realized that the average weight and volume of flesh of the whole predated range of cockles within any one year-class will be greater than the weight and volume of the modal size of those cockles. The modal size will alter, for any one year-class, as one crosses the cockle beds from poor growing ground on the higher levels to good growing ground lower down. In the Burry Inlet the cockle does not increase in length during the winter months, but its internal meat volume declines throughout this period (Hancock 1963). The behaviour of the birds and their movements across the feeding grounds will tend to average out some of these variations, although they seem to feed to a greater extent upon the more densely populated beds.

Bearing these limitations in mind it is still necessary to make some estimate of the food intake. Expressing this as grammes weight or volume will allow direct comparison with the results obtained by other workers. When the figures for the birds' tidal intake of cockles worked out above are multiplied by the appropriate mean weight of flesh of the modal-sized cockle (Table 7), figures for the weight of food consumed per bird per daylight tide are obtained. These totals are respectively: October/November $280 \times 0 \cdot 72 = 202$ g, December/January $204 \times 0 \cdot 73 = 149$ g, and February/March $280 \times 0 \cdot 57 = 159$ g.

These figures compare with the following: 201, 151 and 194 g given by Drinnan (1957) for birds feeding on cockles in Morecambe Bay and Brancaster Harbour; 200 and 250 g (Drinnan 1958*a*) for birds feeding on *Mytilus* at Conway; 146, 121 and 79 g for birds feeding on *Macoma* in the Dutch Waddensea (Hulscher 1964). The figures from the Waddensea were obtained in the summer period, whereas the others were all from winter observations, and this may account for the lower weights consumed.

It has been shown by Drinnan (1957) that the Oystercatcher feeds not only by day but also by night. No observations on night feeding have been made by the writer, so for assessment of the 24-hour intake

of food by the bird it will be assumed that the figures given by Drinnan (1958*b*) are representative and that the night feeding rate is about half that of the daylight rate.

The figures for 1961/62 then become 420, 306 and 420 cockles or 303, 223 and 238 g per bird per day for the three periods October/November, December/January and February/March respectively.

TOTAL CONSUMPTION IN RELATION TO THE STOCKS AND THE FISHERY

To assess the damage done to the cockle fishery the figures for offtake of cockles must be related to total available stocks and the fishery catch. For each two-monthly period during 1961/62 the total number of cockles removed by Oystercatchers has been calculated by multiplying the daily consumption per bird by the average numbers of birds present, and by the number of days concerned:

October/ November	Average number of birds		10 820	×	420 cockles	×	61 days =	277 208 400
December/ January	„	„	11 310	×	306	×	62 „ =	214 523 320
February/ March	„	„	4 140	×	420	×	59 „ =	102 589 200
							Total =	594 370 920

Thus, nearly 600 million cockles were accounted for by Oystercatchers in the winter period October 1961-March 1962. As already stated, the estimate of the percentage feeding rate is considered to be low and the birds were present in considerable numbers from August onward, so the true number of cockles removed by Oystercatchers would seem to have been considerably higher.

No detailed feeding rates are available for the winters of 1962/63 and 1963/64, but an estimate can be made by again using average figures. The average feeding rate for all observations made when the birds were feeding on second-winter cockles is 1·2 cockles per min. Assuming our figure of 55% of the available time spent feeding to be correct, we can multiply this by the number of birds present month by month and achieve a winter total for predation. These figures are set out in Table 9.

The figures for predation in 1964-65, obtained by using the feeding rate calculated on the average of several years, are probably too low. The cockle meat volumes were low during that year (see Table 7) and the feeding rates observed on 18 and 19 February 1965 were very high (2·1 and 1·9 per min during two full days' observations). Using a mean of 2·0 for these higher feeding rates a loss of 1 237 million cockles has been calculated, compared with a loss of 743 million calculated using the average feeding rates of 1·2 cockles per min and 557 million obtained from the observed feeding rate at the end of March 1965. The figures for 1963/64 on the other hand may require adjustment, because no account was taken of the larger numbers of spat cockles eaten. No reliable figures could be obtained for feeding rates of birds feeding on spat, because usually they were taking a mixed diet of spat and second-winter cockles, it being impossible to be sure of distinguishing between the size of cockles being eaten and often difficult even to see whether the birds were, in fact, taking spat, or just randomly probing in the sand.

The condition of the cockle beds, the stock figures and the numbers of birds were all abnormal during the winter 1963/64, as a result of the preceding very severe winter. Therefore the calculations of stock losses and predation for this winter have been omitted from the final summary.

Table 9. *Calculated losses of second-winter cockles due to Oystercatcher predation*

	A		B	C	D		
	Winter feeding period (days)		Average feeding time per bird per 24 hours* (minutes)	Feeding rate (numbers of cockles per minute)	Counts of birds	Numbers of cockles eaten (millions) (A × B × C × D)	Winter losses due to Oystercatchers (millions)
1961/62	October	61	420	1·0†	10 822	277	595
	November						
	December	62		0·73†	11 313	215	
	January						
	February	59		1·0†	4 144	103	
	March						
1962/63	October	31	420	1·2ø	6 200	97	757
	November	30			8 800	133	
	December	31			14 100	220	
	January	31			8 500	133	
	February	28			6 600	93	
	March	31			5 200	81	
1963/64	October	31	420	1·2ø	—	—	240 (5 months only)
	November	30			5 519	83	
	December	31			3 741	58	
	January	31			3 003	47	
	February	29			1 700	25	
	March	31			1 700	27	
1964/65 (a)	October	31	420	1·2ø	7 800	122	743
	November	30			6 800	103	
	December	31			10 500	164	
	January	31			10 500	164	
	February	28			8 500	120	
	March	31			4 500	70	
1964/65 (b)	October	31	420	0·9–2·0†	7 800	91–203	557–1 237
	November	30			6 800	77–171	
	December	31			10 500	123–273	
	January	31			10 500	123–273	
	February	28			8 500	90–200	
	March	31			4 500	53–117	

*Calculated as 55 (=average % of birds feeding) × 510 (=number of minutes, i.e. 8½ hours, for which beds are exposed, per tide) × 3/2 (factor allowing for reduced feeding at night)

† observed feeding rate ø average of observed feeding rates

It is estimated that, in the six winter months October-March of the three winters 1961/62, 1962/63 and 1964/65, Oystercatchers removed from the Burry Inlet total numbers of cockles of 595, 757 and between 557 and 1 237 million respectively. This compares with fished catches for the same winters, but the six months December-May, of 107, 46 and 128 million cockles respectively. Total stocks of cockles aged two winters and older in November of the same years were 1 001, 1 353 and 3 232 million (Hancock and Urquhart, in preparation).

In comparing these figures it must be remembered that the estimates of cockles eaten by the Oystercatcher refer to the whole of the estuary, while the estimates of cockle stocks refer only to the area of the commercial beds. However, the majority of the birds do feed within the area of the commercial fishery. In calculating the consumption by the birds no allowances have been made for the birds present and feeding in August and September. The data from the two winters 1962/63 and 1964/65 for which complete monthly bird counts are available show that it is reasonable to multiply the total numbers of cockles consumed during the months October-March by a factor 1·25, to give a more accurate estimate of the total winter consumption by the birds.

SUMMARY

1. The topography of the Burry Inlet is described.
2. The status of the Oystercatcher (*Haematopus ostralegus* L.) in the Burry Inlet is discussed. Monthly counts made between 1961 and 1965 show maximum winter numbers ranging between 5 500 (1963/64) and 15 800 (1965/66).
3. The daily feeding and roosting movement patterns are described, as well as the winter migratory movements.
4. Evidence from ringing and marking shows that the South Wales population is more or less discrete and centred on the Burry Inlet. Observations of colour-banded birds indicate that a high percentage of the birds present in one autumn return to and remain in the Inlet during subsequent winters.
5. The preference shown by the Oystercatcher for feeding on second-winter cockles is noted and this is seen to bring it into direct competition with the fishermen.
6. Observations made on the mean feeding rate vary from 0·73 cockles per minute to 2·1 cockles per minute, depending largely upon the flesh volume of the cockles involved.
7. Calculations are presented showing that on average the birds feed for 55% of the time during which the cockle beds are uncovered by the tide. The relevant feeding rates for three successive two-monthly observation periods in the winter 1961/62 gave 280, 205 and 280 as the mean numbers of cockles consumed per bird during a daylight tide.
8. By multiplying the number of cockles by the flesh weight at the time of the observations, figures of 202, 149 and 159 g wet flesh were obtained for food intake per daylight tide. The results of other workers are similar to these figures.
9. It is shown that the calculated predation by the Oystercatcher over the three winters 1961/62, 1962/63 and 1964/65 ranged between 557 and 1 237 million of second-winter and older cockles, compared with fished catches of 46-128 million for the same winters and total stocks of only 1 001-3 232 million of the same ages in November of the same years. These figures are not strictly comparable, since there is a larger area of sub-economic stocks available to the birds but not exploited by the fishermen, and there are differences in survey times.

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